1. The scientific basis of MME
2. Status of I-MME
3. How does CPC make its operational (seasonal) predictions
4. CTB projects in MME

Huug van den Dool, Malaquias Pena and Suranjana Saha
Feb, 18, 2011
NMME meeting APL

Joe	45 cm		
Jin	43 cm		
Tony	42 cm		
Bill	43 cm		
Dave	44 cm		

Joe	45 cm		
Jin	43 cm		
Tony	42 cm		
Bill	43 cm		
Dave	44 cm		
average	43.4 cm		

Basis of MME (and many other things):
There is more information in the entries of Table 5 collectively than in any one reading alone.

Where is the uncertainty???

Where is the verification?

A forecast (by a model) is an estimate (“reading”) of some environmental element (temperature) at a future time.

Meteorology is special in two ways

- 1) Skill has to be positive, i.e. not just any reading method will do. Positive skill implies an improvement over a control reading (something any dummy can do , like “climatology”). Error has to be smaller than a control error.

- 2) Accuracy of readings (UKMO, METF, ECMWF, CFSv1, CFSv2) is basically unknown and has to be established from a sample of hindcasts (and matching obs). Give us hindcasts.

			Observations
Joe	$reading_1(t)$	+/- ε_1	obs(t)
Jin	$r_2(t)$	+/- ε_2	obs(t)
Tony	$r_3(t)$	+/- ε_3	obs(t)
Bill	$r_4(t)$	+/- ε_4	obs(t)
Dave	$r_5(t)$	+/- ε_5	obs(t)

ε is estimated from RMSD between r(t) and O(t) over many t. Need hindcasts.

Before we forget: systematic errors

A weighting scheme takes the epsilon into account

Can a model be too inaccurate to be included with equal weight in an Multi Model Average?

- Yes. (short but politically incorrect answer)

  (The more the merrier does not necessarily apply)

- One model: $r_1 +/- \varepsilon_1$
- Two models :

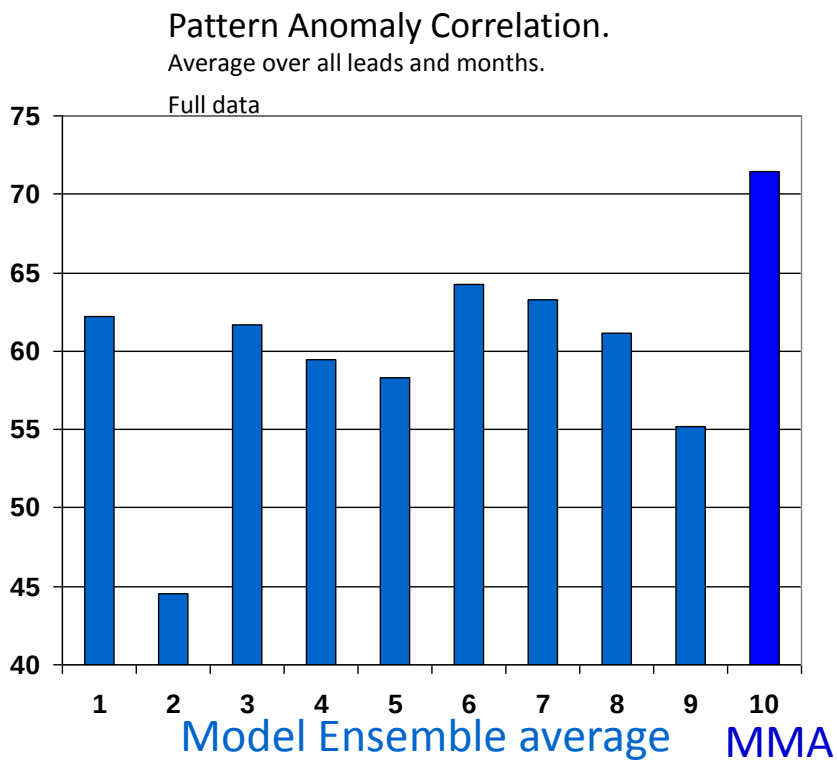
$(r_1+r_2)/2 +/- \text{sqrt}(\varepsilon_1 * \varepsilon_1 + \varepsilon_2 * \varepsilon_2) /2$

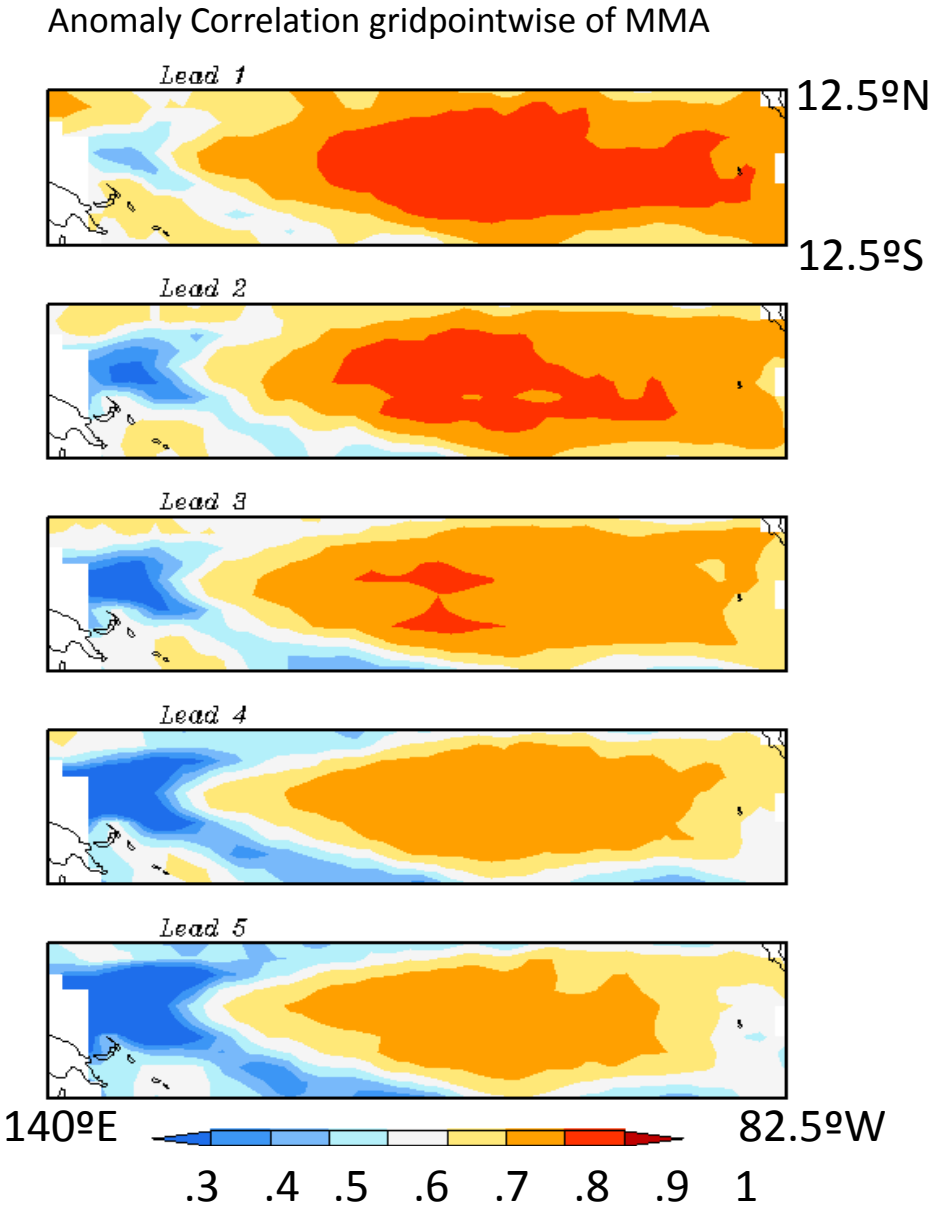
$= (r_1+r_2)/2 +/- \varepsilon_1 /\sqrt{2}$ (if $\varepsilon_2 = \varepsilon_1$) . This is good

$= (r_1+r_2)/2 +/- \varepsilon_1$ (if $\varepsilon_2 = \sqrt{3}\ \varepsilon_1$) . This is not good enough. If $\varepsilon_2 > \sqrt{3}\ \varepsilon_1$ it would hurt to include model # 2 with equal weight.

- Non-equal weights may address this, but this further increases the demands on hindcasts (longer please). How accurately do we know the ε_i ???

Tropical Pacific SST





- Region of appreciable skill
- Multi-Model Ensemble Average (MMA) more skillful than any single ensemble model average
- Can sophisticated consolidation methods be better?

Has NCEP done MME?

- Yes, since ~1970, subjectively
- NAEFS → NOUPSI

Scientific basis of MME ……

- ME (Model Ensembles, with IC perturbed)
- mME (purposely perturbed in-house models and IC), different plug-in physics, stochastic processes
- MME (multi-institution)

→ *ME has the advantage of equal models and equal members. A-priori: all* ε_i *are the same.*

→ *mME has the advantage of in-house control*

→ *Formal MME has turned out to be not-so-easy*

In the limit of a perfect model:

- MME → ME, so what is the role of model diversity ultimately???
- How far are we removed from this type of perfection??? How to test???
- Does MME do anything more than increase the size of the ensemble of a single model???
- MME is no substitute for model development

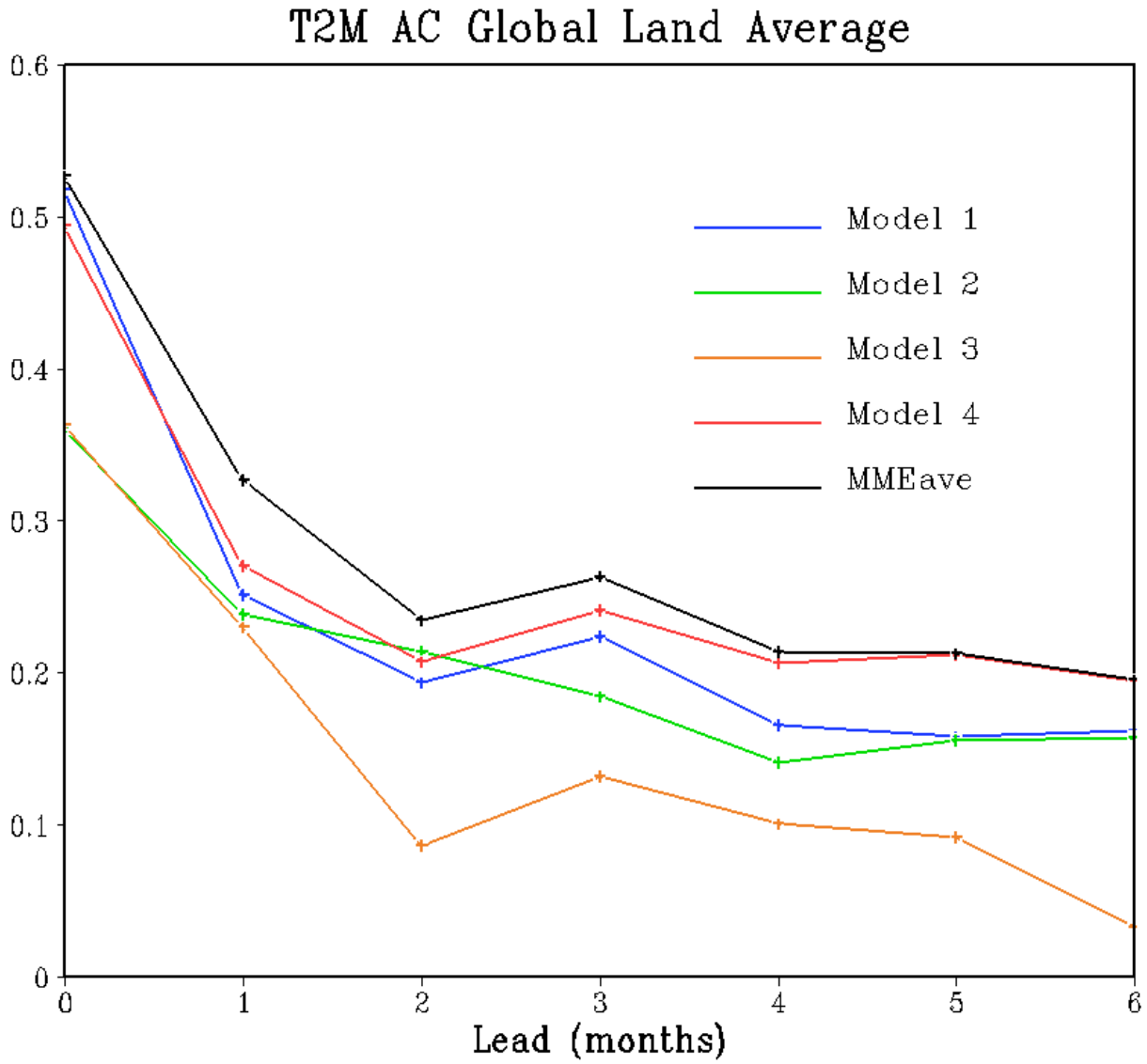
IMME

- NCEP was admitted as ‘associate’ partner as per MOU in summer 2010.
- Player: ECMWF, MeteoFrance, UKMO, NCEP-CFS
- Germany may join
- Technical meeting Feb 22
- Steering group meeting Feb 23
- Both ECMWF and NCEP are changing models. UKMO has recently changed strategy.
- Rules of engagement.

About the EUROSIP hindcasts:

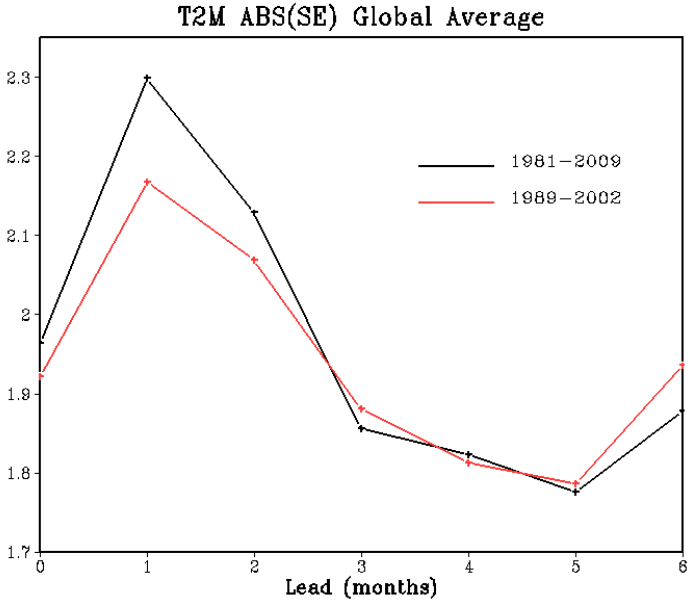
	years	Ens size	Start months	lead	
US CFSv2	1982-2009	24-28	12	0-8 months	
EC/s3	1981-2009	11	12	0-7	
UK	1989-2002	12	11	0-6	
MetF	1981-2009	11	12	0-6	

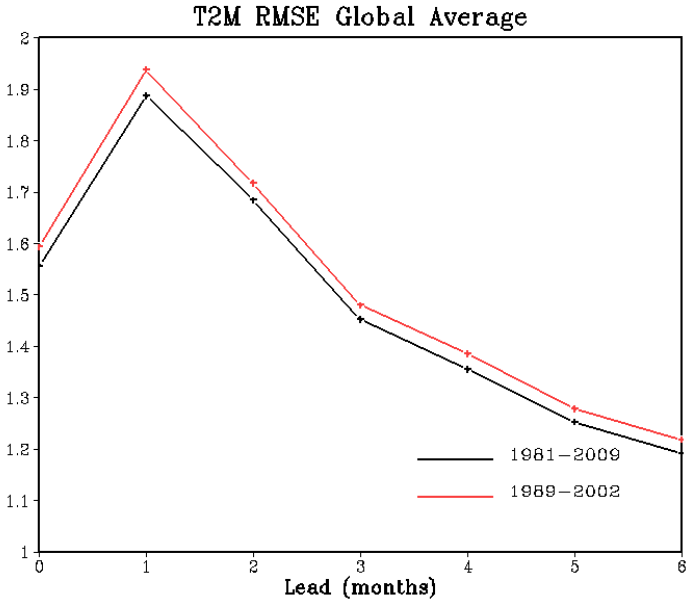
MME average outperforms the other members for 2m T

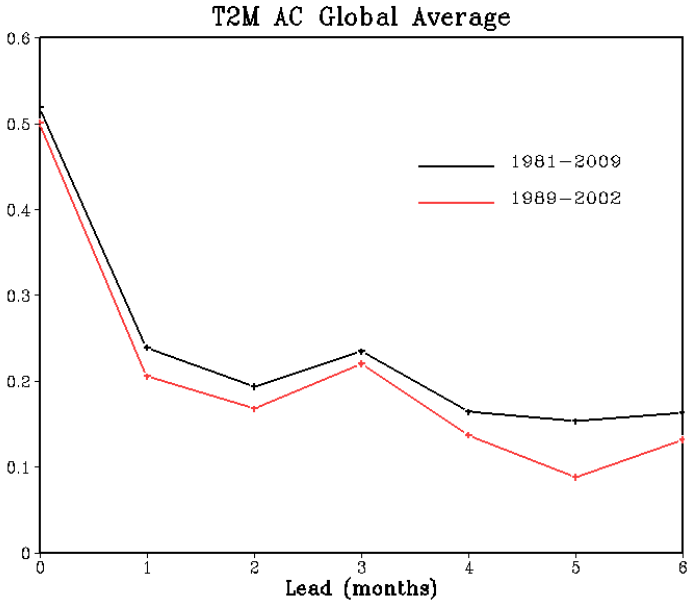


IC Jan 1982-2008; Full data

1981-2009 vs. 1989-2002







model 1

How does CPC make its operational monthly/seasonal prediction??

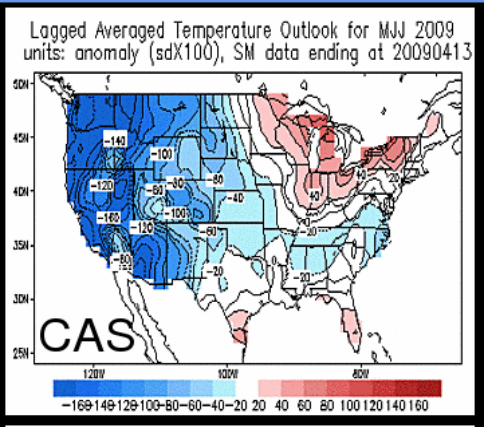
Seminar next Wednesday. Should help R2O

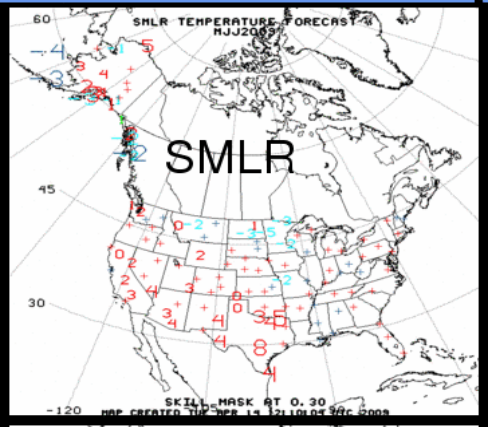
Menu of CPC predictions:

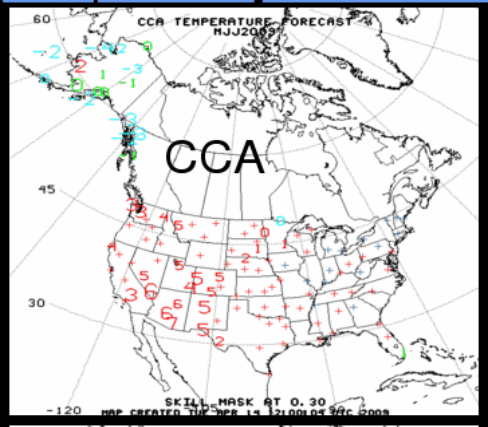
- 6-10 day (daily)
- Week 2 (daily)
- Monthly (monthly + update)
- Seasonal (monthly)
- Other (hazards, drought monitor, drought outlook, MJO, UV-index, degree days, POE, SST) (some are 'briefings')
- Informal forecast *tools* (too many to list)

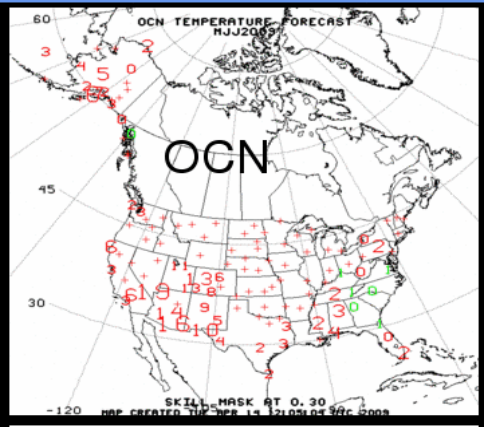
- http://www.cpc.ncep.noaa.gov/products/predictions/90day/tools/briefing/index.pri.html

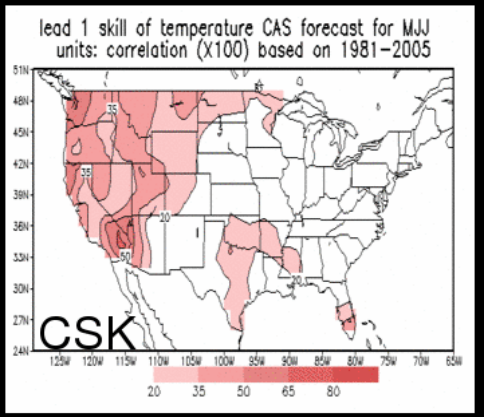
MJJ Season [Temperature]

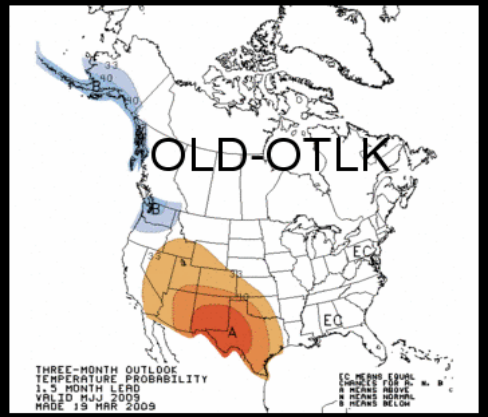


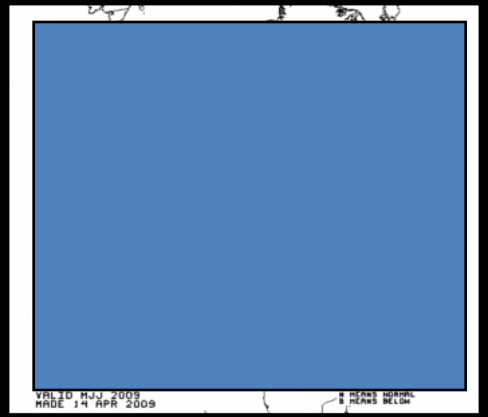


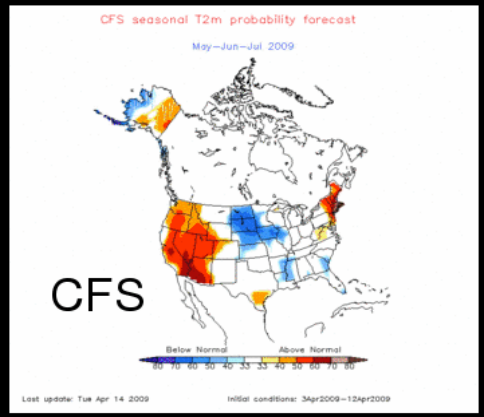


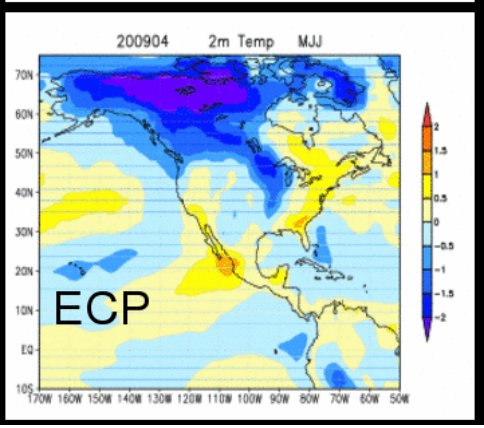


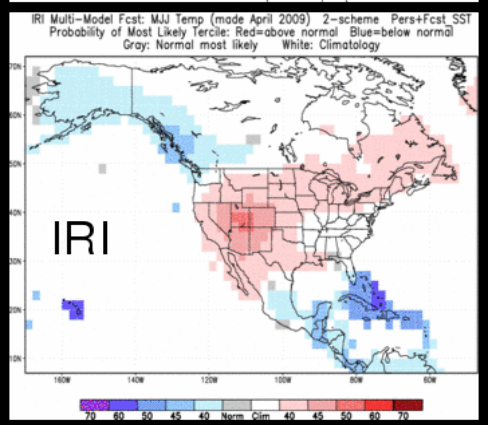


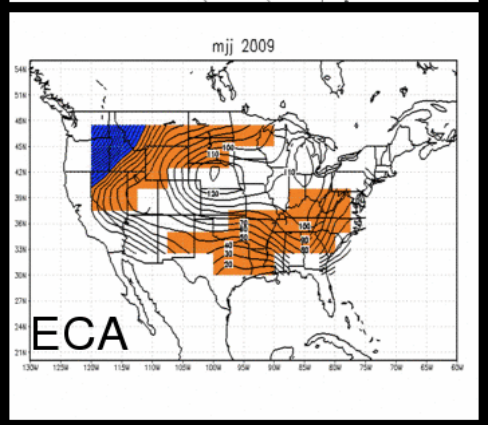


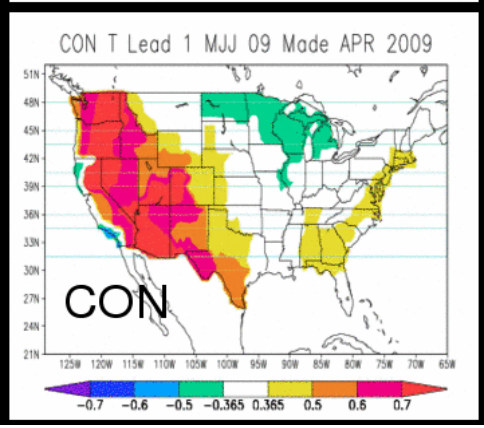




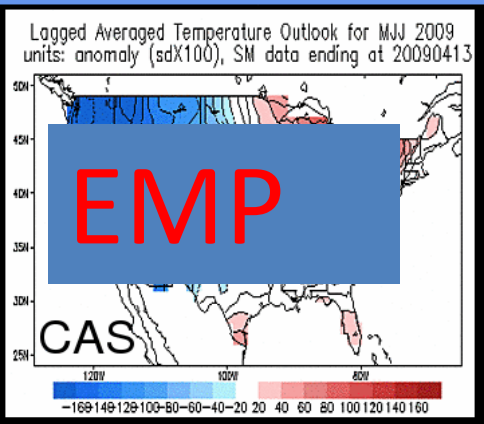


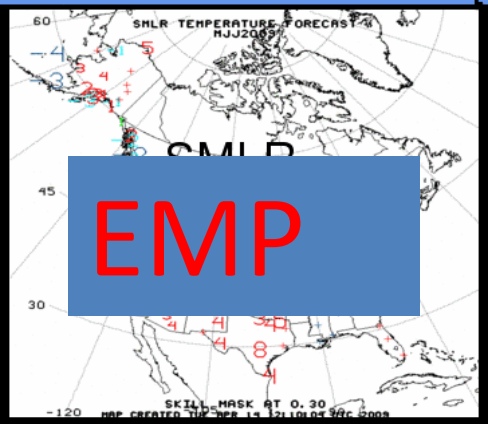


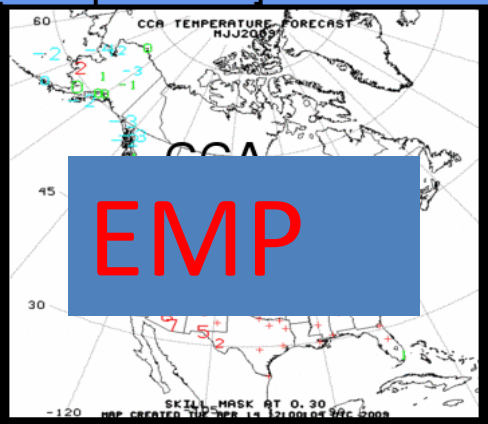


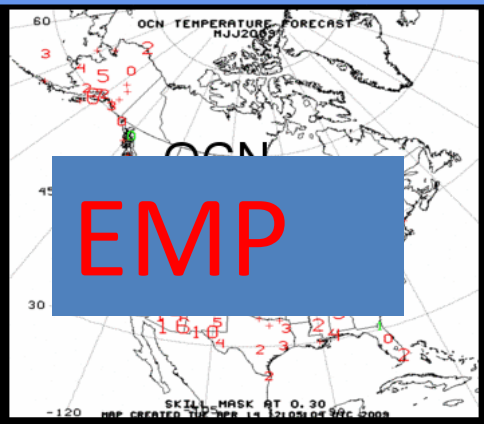


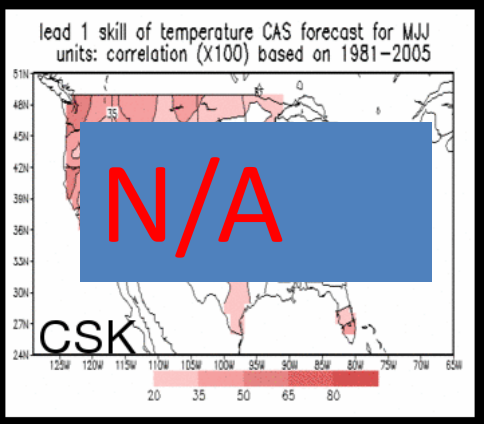
MJJ Season [Temperature]

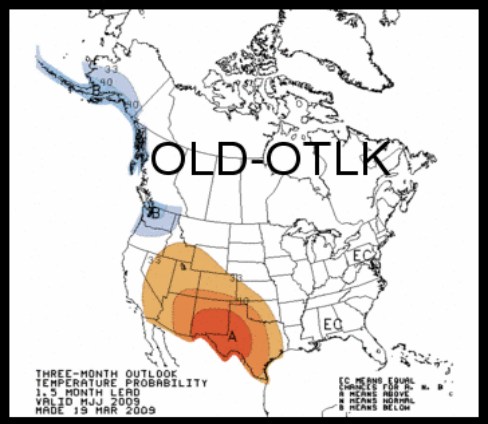


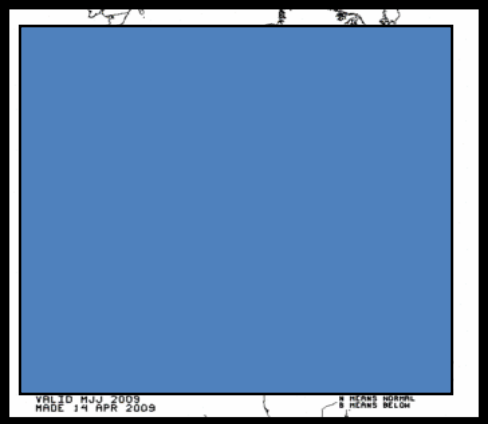


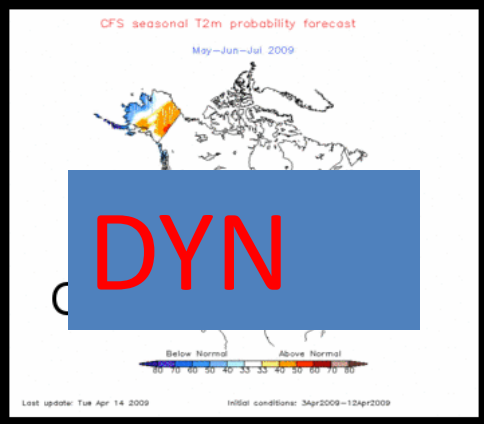


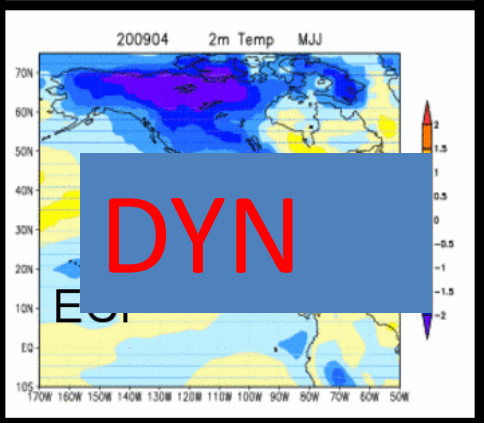


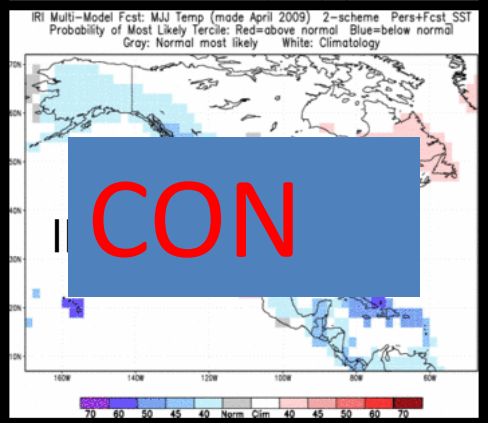


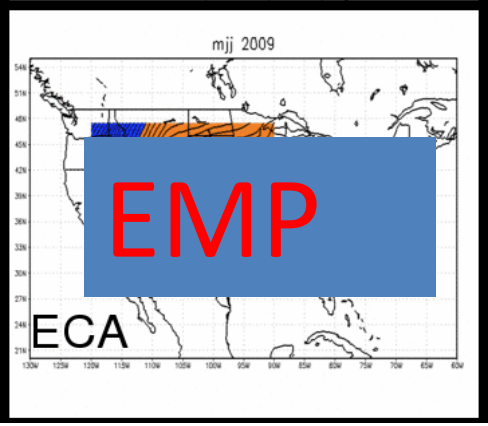


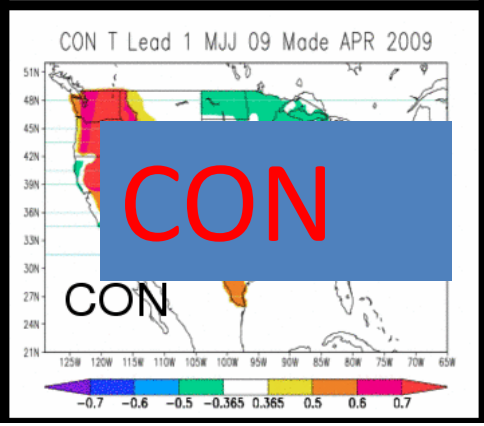




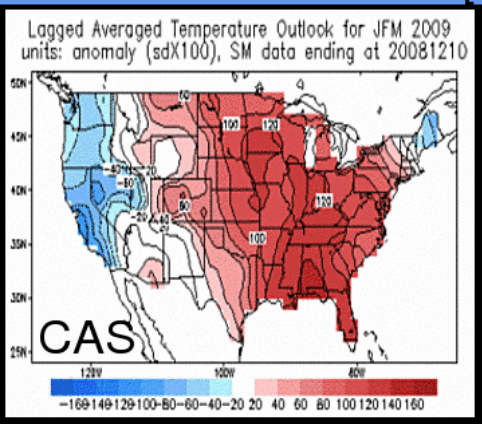


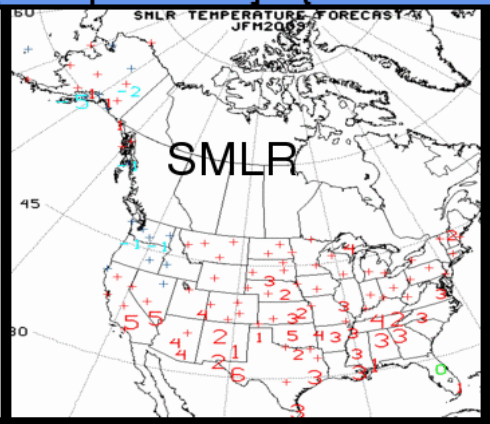


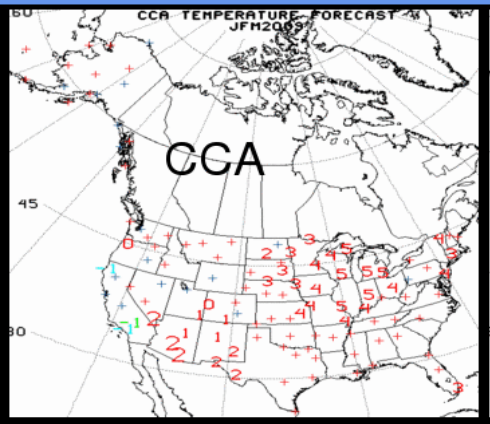


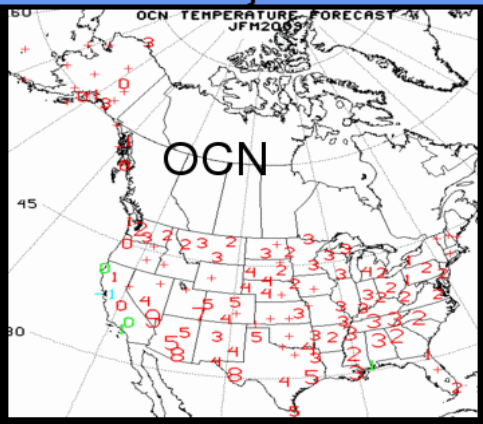


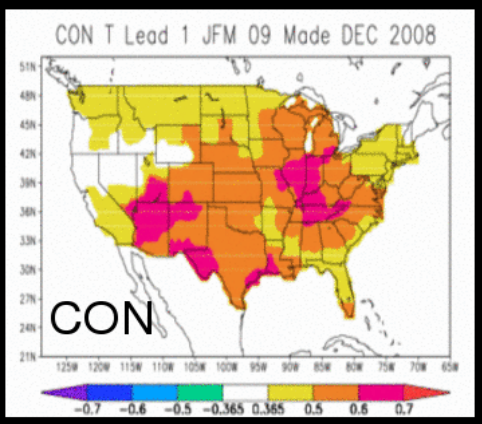
JFM Season [Temperature] {ALL: +10.1 / NON-EC: +16.6 / %-COVG: 61.2}

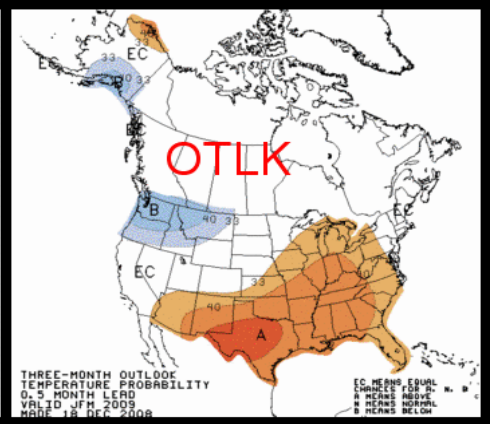


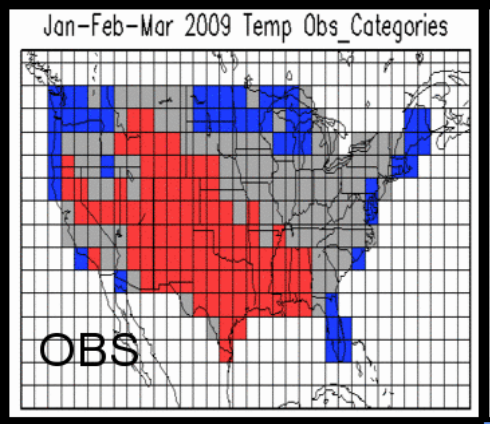


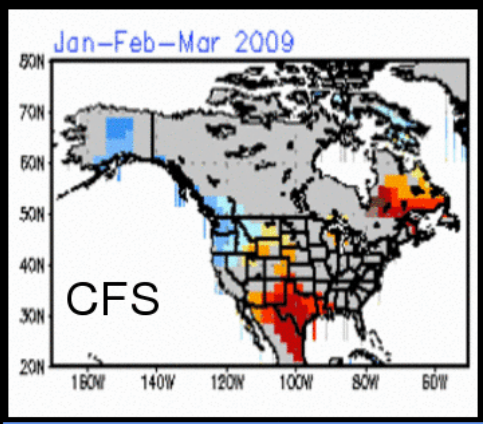


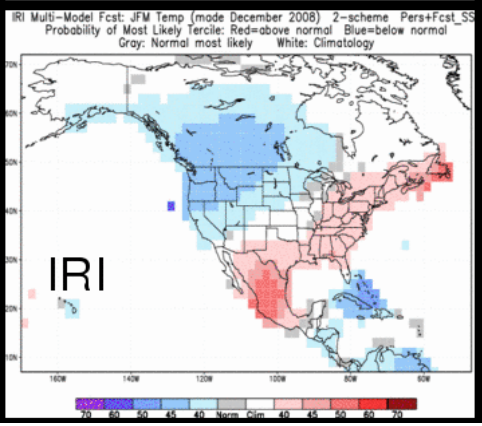


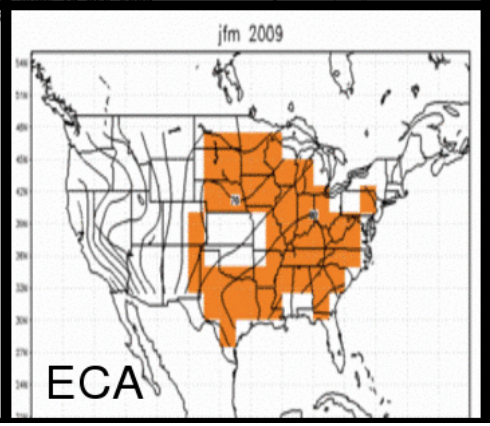


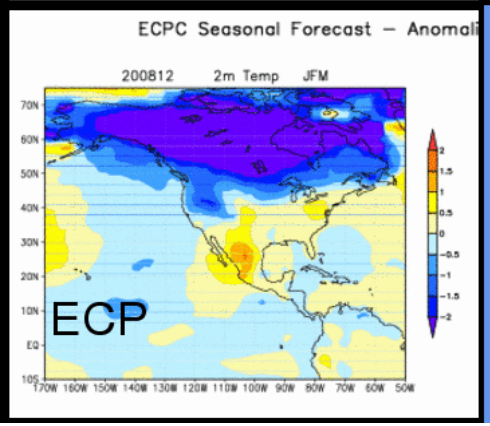












Element →	US-T	US-P	SST	US-soil moisture
Method:				
CCA	X	X	X	
OCN	X	X		
CFS	X	X	X	X
SMLR	X	X		
ECCA	X	X		
Consolidation	X	X	X	
Constr Analog	X	X	X	X
Markov			X	
ENSO Composite	X	X		
Other (GCM) models (IRI, ECHAM, NCAR, CDC etc):	X	X		

CCA = Canonical Correlation Analysis
OCN = Optimal Climate Normals
CFS = Climate Forecast System (Coupled Ocean-Atmosphere Model)
SMLR = Stepwise Multiple Linear Regression
CON = Consolidation

OFFicial Forecast(element, lead, location, initial month) =

a * A + b * B + c * C +

...

Honest hindcast required over many years.

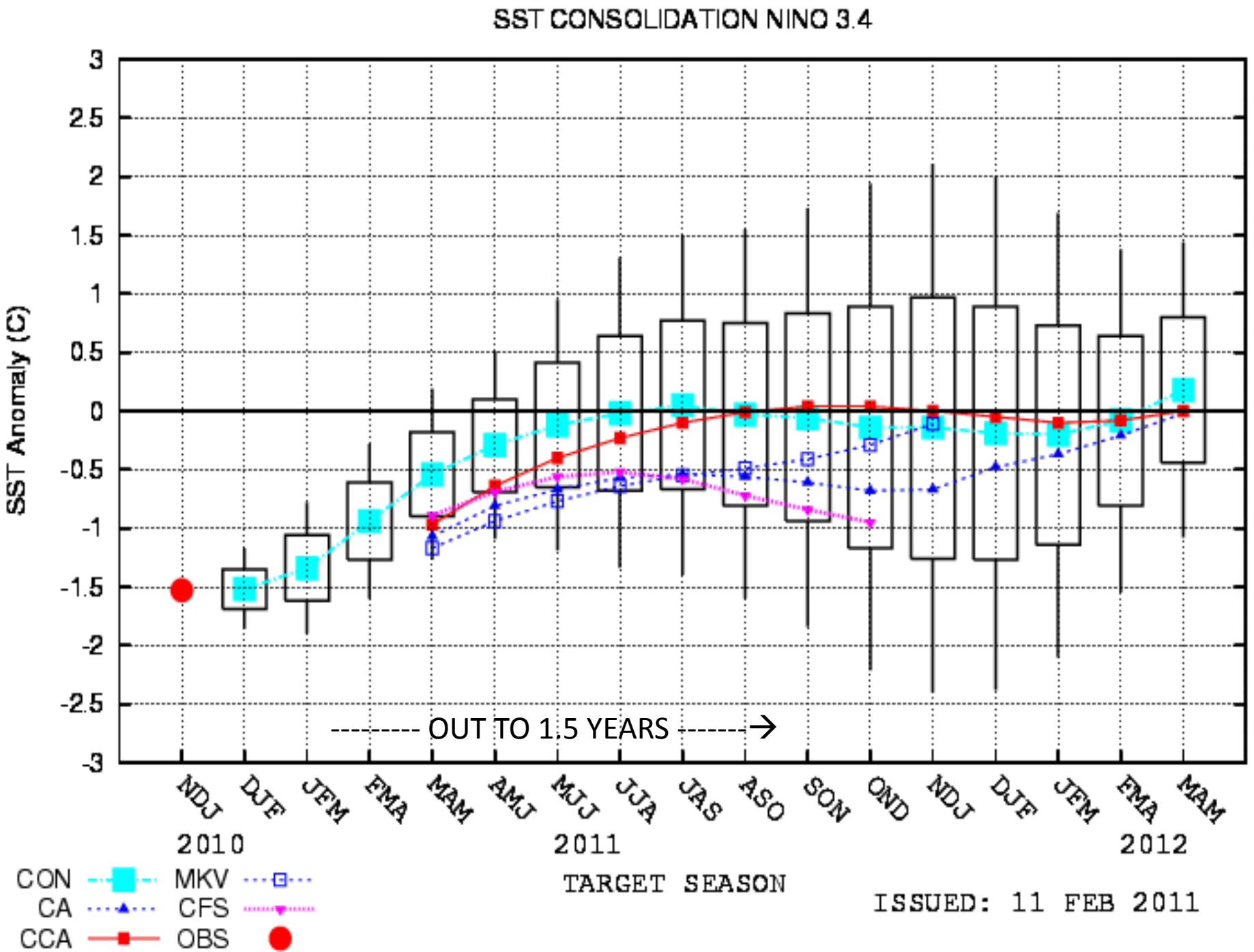
Covariance (A,B), (A,C), (B,C), and

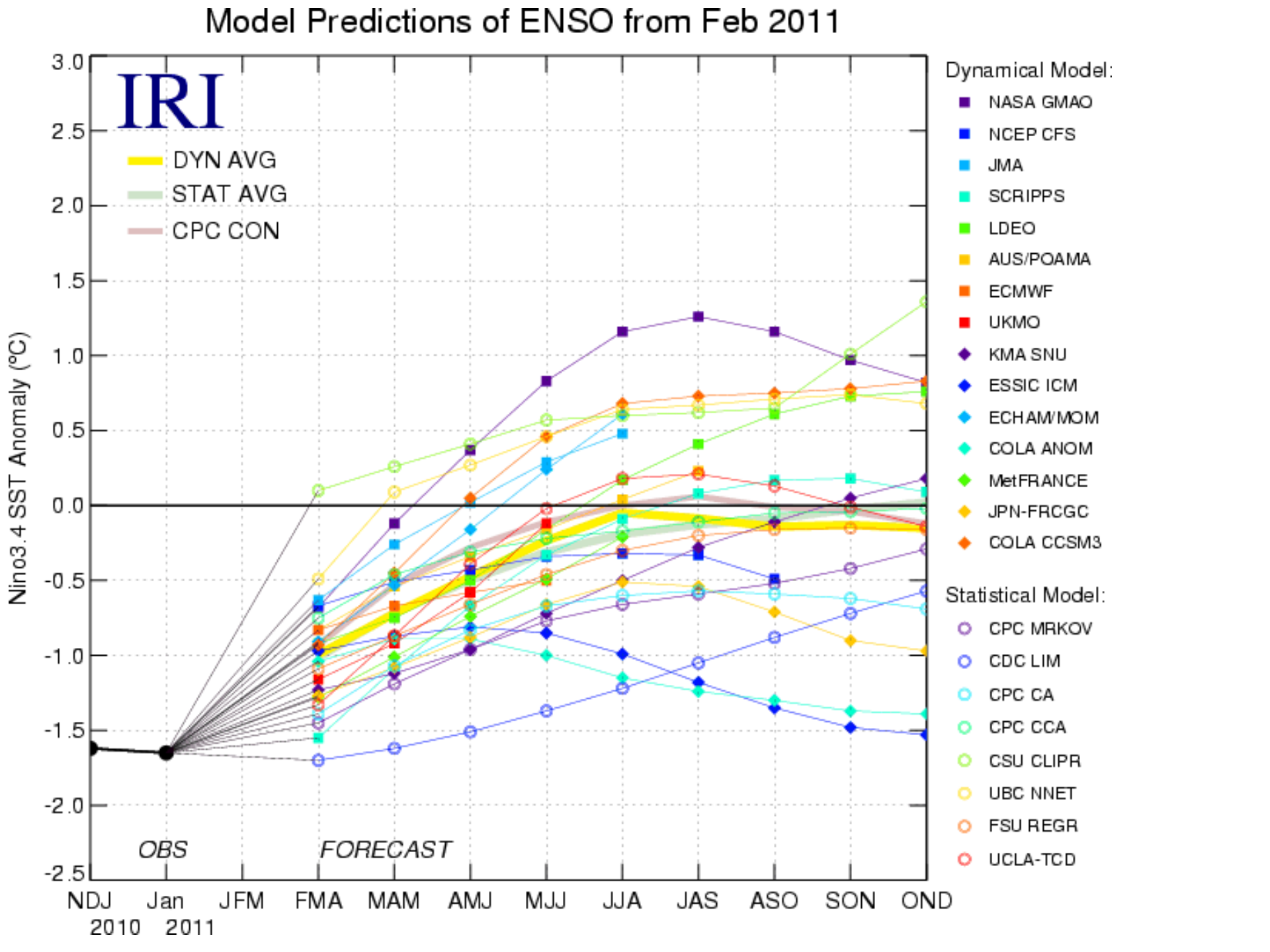
(A, obs), (B, obs), (C, obs) allows solution for a, b, c

(element, lead, location, initial month)

M. Peña Mendez and H. van den Dool, 2008: Consolidation of Multi-Method Forecasts at CPC.
J. Climate, **21**, 6521–6538.

Unger, D., H. van den Dool, E. O'Lenic and D. Collins, 2009: Ensemble Regression.
Monthly Weather Review, **137***,* 2365-2379*.*


SST CONSOLIDATION NINO 3.4
SST Anomaly (C)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
--------- OUT TO 1.5 YEARS ------→
NDJ
DJE
JFM
FMA
MAM
AMJ
MJJ
JJA
JAS
ASO
SON
OND
NDJ
DJE
JFM
FMA
MAM
2010
2011
2012
TARGET SEASON
CON
CA
CCA
MKV
CFS
OBS
ISSUED: 11 FEB 2011


Model Predictions of ENSO from Feb 2011
IRI
DYN AVG
STAT AVG
CPC CON
Nino3.4 SST Anomaly (°C)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
OBS
FORECAST
NDJ
2010
Jan
2011
JFM
FMA
MAM
AMJ
MJJ
JJA
JAS
ASO
SON
OND
Dynamical Model:
NASA GMAO
NCEP CFS
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
ESSIC ICM
ECHAM/MOM
COLA ANOM
MetFRANCE
JPN-FRCGC
COLA CCSM3
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD

Current lines of CTB development

- CTB-MME
  - Ben Kirtman et al (CCSM3.0, 3.5 and 4.0) with CFS
  - Lisa Goddard et al (IRI; post-processing methods)
  - Tim delSole et al (COLA; post-processing)
- International MME
  - ECMWF
  - UKmet
  - MeteoFrance